

Radar and Optical Investigations of ACTIVE Experiments
from Millstone Hill

NAG 5 1343

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Final Technical Report
Report Period: 5/1/90 - 4/30/91

August 27, 1991

(NASA-CR-193773) RADAR AND OPTICAL
INVESTIGATIONS OF ACTIVE
EXPERIMENTS FROM MILLSTONE HILL
Final Technical Report, 1 May 1990
- 30 Apr. 1991 (MIT) 6 p

N94-70432

Unclass

Z9/32 0181228

A series of ionospheric plasma diagnostic experiments were performed with the MIT Millstone Hill UHF radar in conjunction with ACTIVNY satellite overflights and requested active experiments during the interval between December 1989 and March 1991. Radar diagnostics and satellite tracking were nominal during the experiments, but no effects of the active experiments were observed. In a number of instances, the requested active perturbation was not performed and low transmitted VLF power from ACTIVNY is believed to have caused in the null results in the other experiments. In April, 1991, at the end of the first year of funding, further work on this program was terminated at the request of NASA.

During the course of this grant, analysis was completed for Millstone Hill incoherent scatter radar data taken in conjunction with the ACTIVNY satellite during 1989 and early-1990 experiments. In each of the experiments, the Millstone Hill ephemeris values for the ACTIVNY satellite were used to design an experiment in which the radar followed the position of the satellite, with a specified angular offset, during a satellite overflight of the radar field of view. VLF-G transmitter operations, or in the case of the 27 Dec 89 experiment a Xenon release, were requested along a specific portion of the overflight trajectory and the radar data were searched for any effect of the VLF transmitter. Specifically, we looked for evidence of enhanced radar backscatter (cf Foster et al., GRL, 15, 1988) due to the growth of ion acoustic or lower hybrid waves in the VLF-perturbed ionosphere. The requested satellite operations were not performed for two of the experiments and no unequivocal effects of the VLF transmitter could be found in the other data sets.

The following table lists the experiment intervals and the status of ACTIVNY operations.

ACTIVE Experiments at Millstone Hill

Date	Radar Operations UT	ACTIVNY UT
13 Dec 89	22:45 - 23:38	23:06-23:17 (G5)
19 Dec 89	21:04 - 22:53	No Recordings
21 Dec 89	21:02 - 23:13	None
27 Dec 89	19:05 - 22:24	21:23-21:24 (Xenon)
28 Dec 89	19:43 - 21:10	20:24-20:32 (G3)
04 Jan 90	19:36 - 20:56	None
20 Mar 90	22:51 - 23:50	Yes
21 Mar 90	22:21 - 22:35	Yes
04 Mar 91	07:56 - 10:35	Unknown (Plasma Gun)

Analyzed Experimental Results: Representative experimental results are shown in Figures 1 and 2 which display radar backscattered power during the Dec 13, 1989 and Dec 27, 1989 overflights during which VLF-G and Xenon release, respectively, operations were confirmed. The radar tracked the satellite with the beam offset by two beam widths on Dec 13th and set near the satellite position on Dec 27th. Detailed spectral analysis does not reveal any sustained ion acoustic wave growth during either of these experiments, although one instance of enhanced acoustic backscatter in the vicinity of the satellite was found during the Dec 13, 1989 event (see Figure 3). There is no evidence, however, that this was not due to natural geophysical processes.

On Dec 19, 1989, an experiment was requested by the Soviet team members to calibrate the on-board ACTIVNY electron temperature probe. Detailed radar profiles of ionospheric density and temperature extending through the 600 km altitude of the satellite were produced (Figure 4) and sent directly to Dr. V. Shevchenko for transmittal to the ACTIVNY experiment team. Unfortunately, no on-board data were recorded during the satellite pass over Millstone Hill on that night.

Additional Experiments: In June, 1990 Dr. F. Djuth (Aerospace Corp.) requested support of the Millstone Hill radar to perform a number of high resolution experiments searching for enhanced plasma waves triggered by the ACTIVNY VLF-G transmitter. A three-day program was supported at the site and data were taken in conjunction with satellite overflights on June 19 & 20, 1990.

During the second half of the interval, since the first interim report was prepared, a final experiment to look for induced plasma effects in conjunction with the firing of the ACTIVNY plasma gun was conducted at Millstone Hill on March 4, 1991. F. Djuth and K. Groves collaborated in requesting the Soviet experimenters to activate the plasma gun on a nighttime pass over Millstone Hill and the radar performed elevation scans to determine background parameters and tracked the overflight using the locally generated ephemeris. No effects were observed in the radar diagnostic data and confirmation of plasma gun activation has not been received.

Meetings & Data Presentation: The Principal Investigator participated in the ACTIVE planning session at Goddard Space Flight Center on Dec 12-13, 1989 and the ACTIVE experimenters meeting in Ballston, Va on May 4-5, 1990. At the latter meeting, analyzed results from the Millstone Hill experiments were presented and distributed to the participants. In addition, the Principal Investigator attended a ACTIVNY working meeting in Prague during August, 1990. At that time it was determined that little data were available for comparison with the radar experiments.

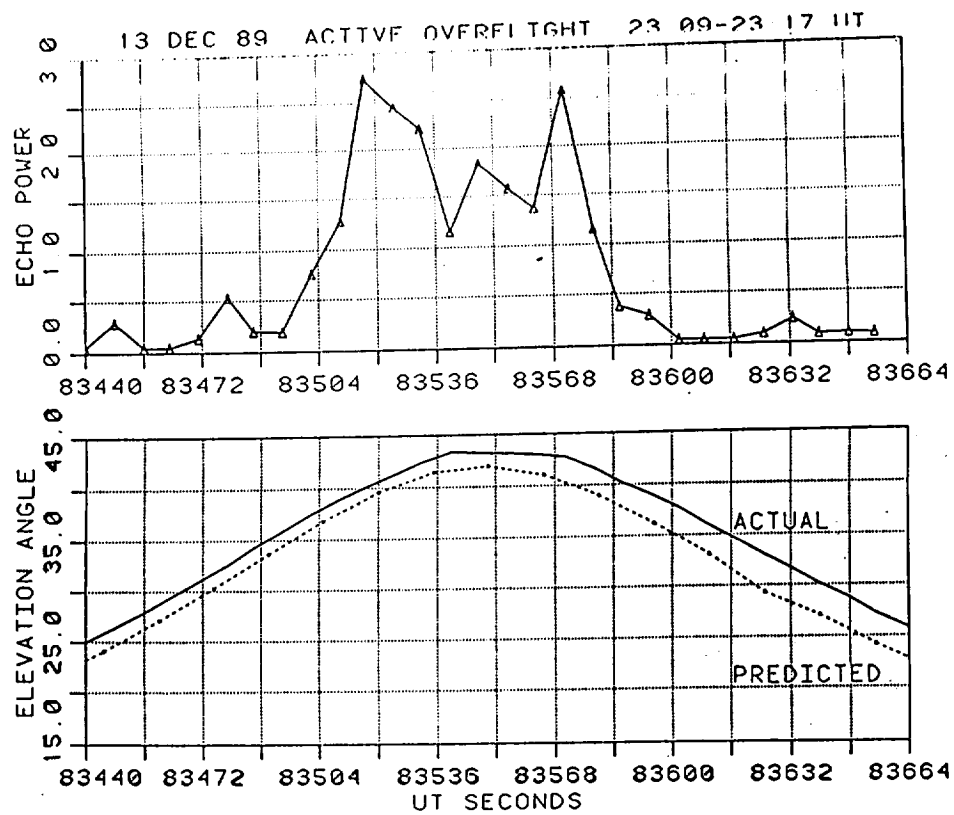


Figure 1

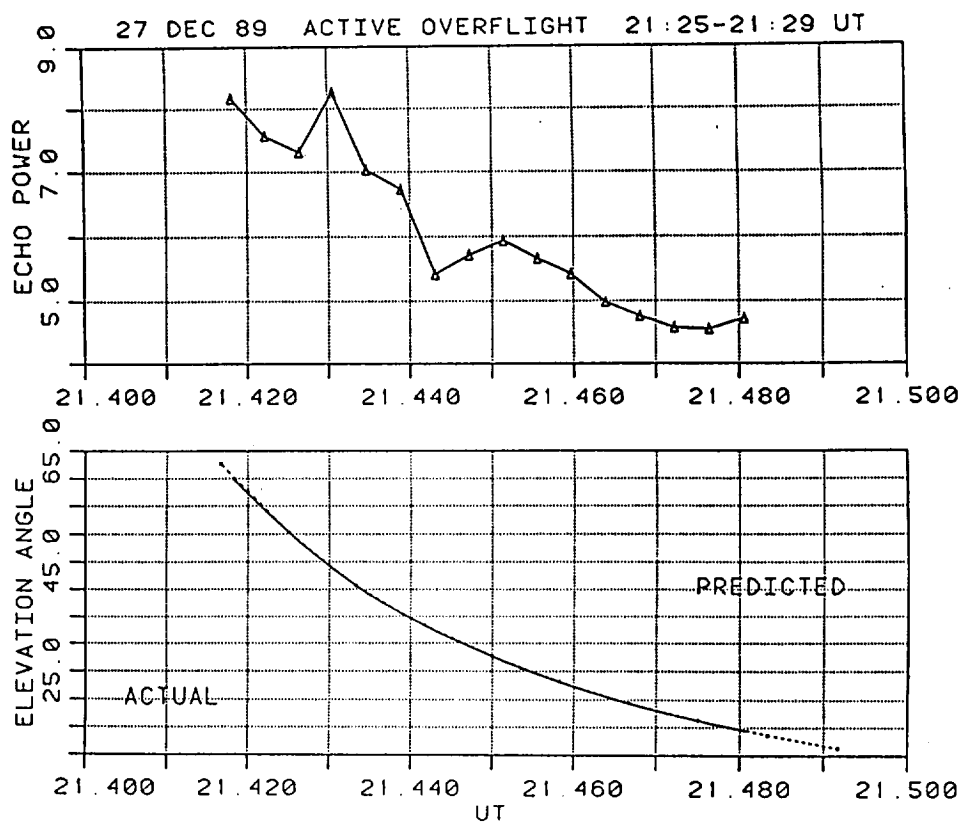
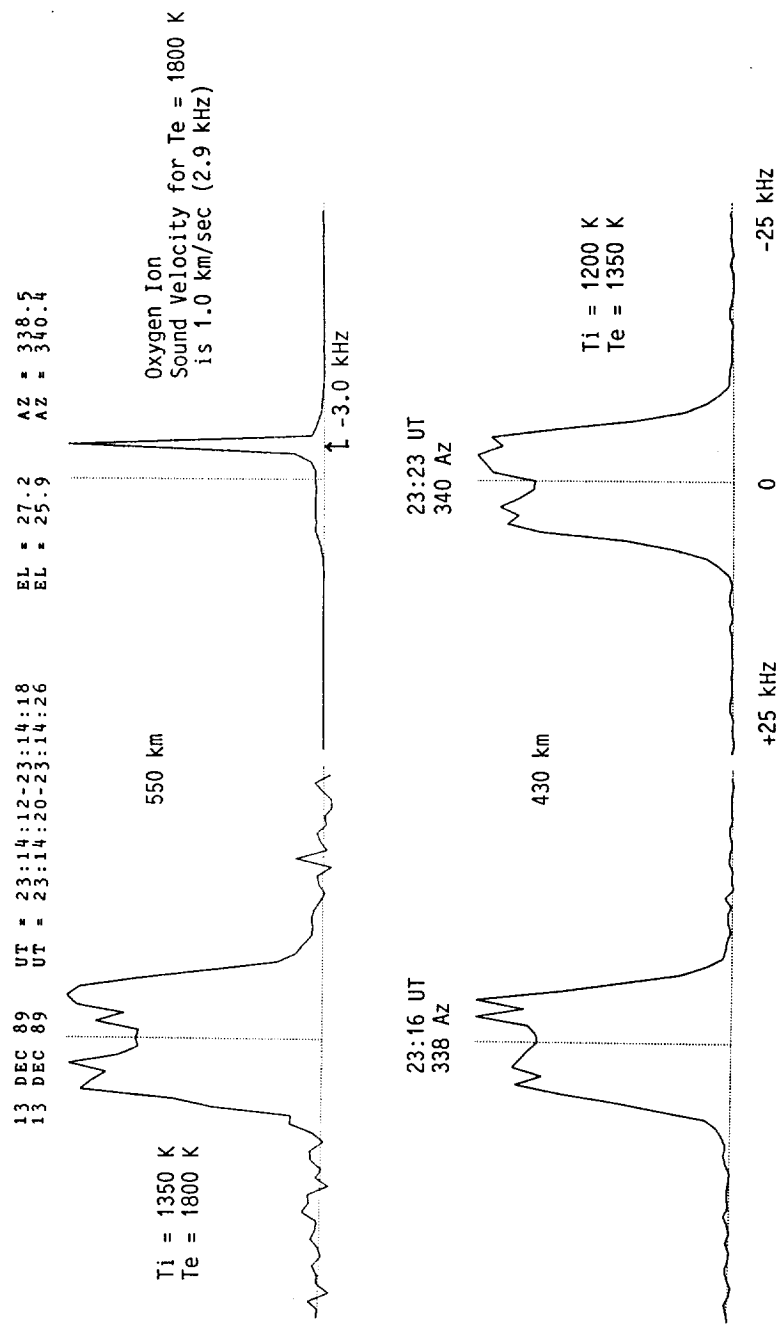


Figure 2



Normalized Backscatter
 Frequency Spectra

Millstone Hill
 440 MHz Radar

Figure 3

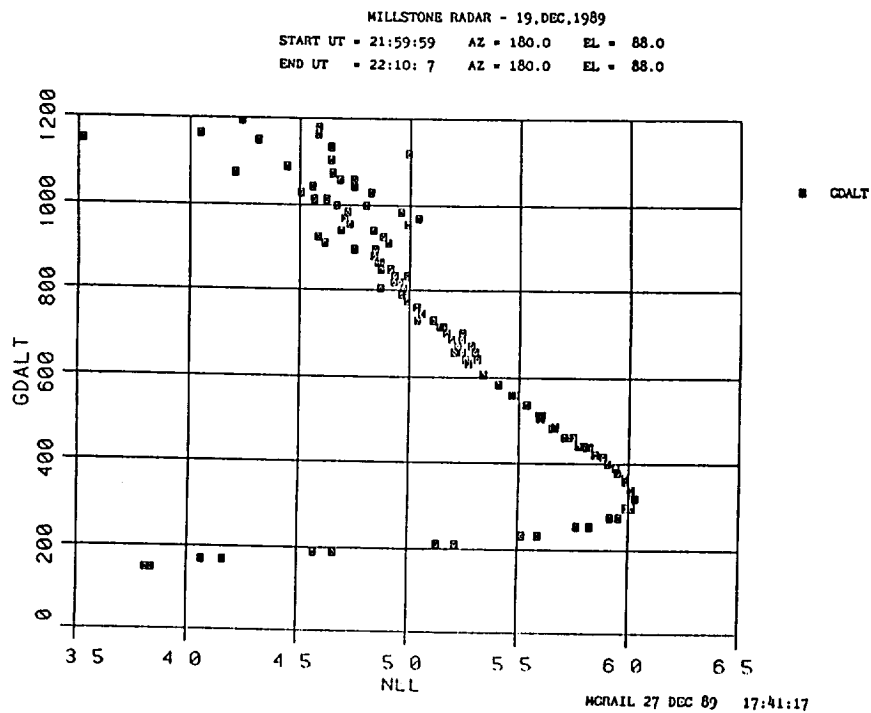
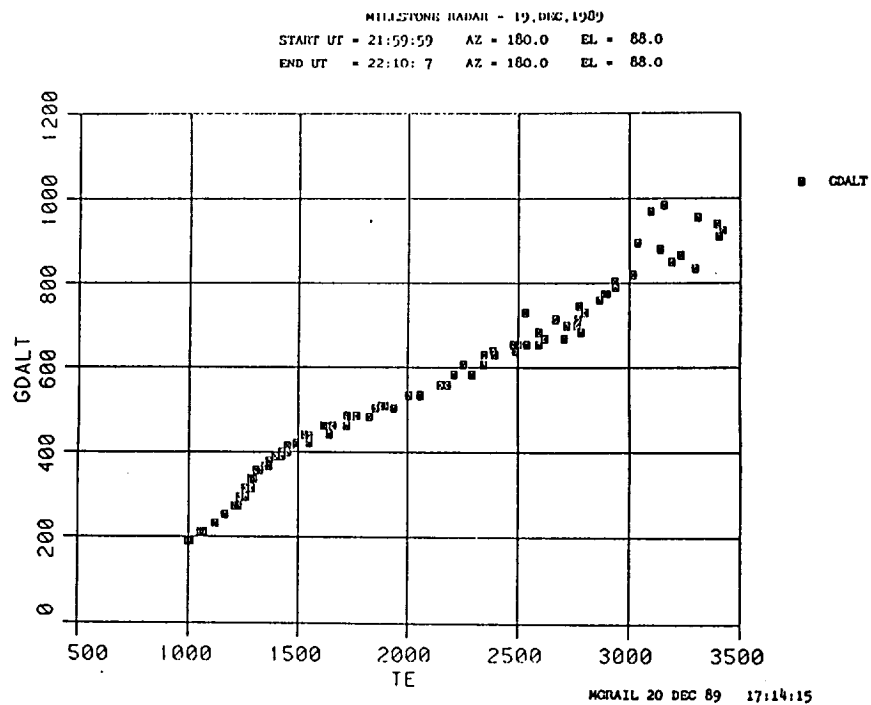


Figure 4
 Electron Temperature (top)
 Log Density (cm^{-3}) (bottom)